

RETAILER LOCATIONS, LOCAL SUPPLY AND PRICE POLICIES*

Carlos Gutiérrez-Hita and Martin Peitz**

WP-AD 2001-26

Correspondence to: Carlos Gutiérrez-Hita. University of Alicante. Dpto. Fundamentos del Análisis Económico. Apdo. Correos, 99, 03080 Alicante. Tel.: +34 96 590 3400 Ext. 2627 / Fax: +34 96 590 3898 / e-mail: charlie@merlin.fae.ua.es.

Editor: Instituto Valenciano de Investigaciones Económicas, S.A.

First Edition October 2001.

Depósito Legal: V-4062-2001

IVIE working papers offer in advance the results of economic research under way in order to encourage a discussion process before sending them to scientific journals for their final publication.

* Carlos Gutiérrez-Hita acknowledges financial support from the Instituto Valenciano de Investigaciones Económicas, Martin Peitz from the Instituto Valenciano de Investigaciones Económicas and Deutsche Forschungsgemeinschaft (Heisenberg fellowship).

** C. Gutiérrez-Hita: University of Alicante; M. Peitz: University of Alicante and University of Frankfurt.

RETAILER LOCATIONS, LOCAL SUPPLY AND PRICE POLICIES

Carlos Gutiérrez-Hita and Martin Peitz

ABSTRACT

Two retailers operate in a monopsonistic, oligopolistic environment. They have to buy from spatially dispersed suppliers and use uniform pricing downstream. We characterize prices and location in the two-stage location-then-price game under two different pricing policies in the upstream market: uniform pricing and spatial price discrimination. We analyze how local supply conditions affect equilibrium locations and profits. We show that if retailers can choose a price policy initially they commit to uniform pricing in the upstream market.

KEYWORDS: Spatial Competition; Intermediation; Uniform Pricing, Spatial Price Discrimination

1. Introduction

It is well known that the location of retailers in space depends on the location of consumers. In a model of price competition retailers have an incentive to relax price competition by moving apart. However, the further they move away from each other the larger the distance becomes to its consumers which in effect makes retailers not to differentiate themselves too much in location. This lesson has been learned by the classic paper by D'Aspremont, Gabszewicz and Thisse (1979) which also applies to retailers (such as the ice-cream vendor on the beach).

In this paper, we concentrate on supply conditions. In order to reach consumers, the product has to be shipped from the manufacturer to the retailer and from the retailer to the consumer. We postulate that supply is competitive for each retailer so that each retailer is a monopsonist upstream, that is, retailers make take-it or leave-it offers to their suppliers. We distinguish between uniform pricing, according to which retailers offer the same wholesale price to all of its potential suppliers, and spatial price discrimination, according to which each retailer can make targeted take-it or leave-it offers. Manufacturers are assumed to have constant and identical marginal costs of production so that the transportation cost to ship the good from the manufacturer to its retailer's store is the only effective difference between manufacturers of one retailer. This translates into an increase in the marginal costs of a retailer when increasing supply and in effect relaxes price competition between retailers. Note that the retailer's marginal cost would be constant in a model in which the transportation costs for shipments between manufacturer and retailer are zero.

Supply functions for each retailer depend on the pricing policy and the distribution of manufacturers. First, we consider a localized but non-constrained version of supply according to which the manufacturers of a retailer are uniformly distributed around the retailers' locations. Second, we consider a localized and constrained version according to which manufacturers are located according to the same distribution function as consumers (because, for example, consumers are also producers). We analyze in which way locational constraints on supply affect equilibrium prices and locations (under uniform pricing and spatial price discrimination).¹

One may see the pricing behavior of retailers as part of the market environment which is exogenous. To this respect we ask in which way different market environments affect the pricing and location of retailers and contrast uniform pricing with spatial price discrimination in the upstream market. We then make the choice of price policy endogenous and show that retailers commit to uniform

¹ In this idealized environment we ignore the possibility to open more than one store (for this see Champsaur and Rochet, 1989, under constant marginal costs for retailers).

pricing in the upstream market although this is more costly.

In our model we have to take rationing into account. Since an increase in supply is costly for retailers, there exist price combinations in which consumers are rationed. Clearly, rationing is never a best response. We make the assumption on consumer behavior that they choose their favorite retailer discarding the possibility of rationing. Since rationing does not occur in equilibrium, these bounded rational consumers obtain as much utility as consumers who were aware of the possibility of rationing.

Although our model should be seen as an abstract framework to address the impact of local supply and pricing policies, it seems to us that it captures an important aspect of the locational choice of retailers. As an example, one can think of markets for agricultural goods where there are many farmers and consumers allocated in a same geographical space (although according to different distribution functions). Farmers sell their harvest to a few shops and these shops sell the product to consumers. Another example could be markets for used cars and other second-hand durable goods in a geographical area. Owners of first-hand cars want to sell their product but need a dealer who certifies the quality of the product. The dealer then sells the second-hand cars to consumers.

There exist many reasons why manufacturers and consumers do need intermediaries to sell and buy goods (see Spulber, 1999). It is not the purpose of this paper to model these reasons, we rather take it as given that manufacturers cannot sell directly to consumers. In contrast to most of the literature on vertically related markets (see, for instance, Tirole, 1988) we give all the market power to the retailer; that is, they are monopsonists upstream and compete as oligopolists downstream. Suppliers and consumers take prices or price schedules as given. This is motivated by evidence that in many manufacturer-retailer relationships market power mainly rests with the retailer.

Our paper relates to the literature inspired by Hotelling (1929) in which the main aim was to explain market power under price competition which arises from the use of differentiation strategies. The endogenous choice of location, which determines the degree of product differentiation under horizontal differentiation, has received a lot of attention (see e.g. D'Aspremont, Gabszewicz and Thisse, 1979, de Palma et al., 1985, Economides, 1986, Böckem, 1994, Bester, 1998). Our paper shows that under uniform pricing supply conditions affect the incentives to horizontally differentiate. In particular, more localized supply leads to higher profits even though firms locate closer to each other. This is due to more localized supply generating higher marginal costs thus making retailers less aggressive.

Different pricing policies, and in particular spatial price discrimination, have been an important research topic in the Hotelling framework (see Greenhut and Greenhut, 1975, Spulber, 1981, Norman, 1983, Lederer and Hurter, 1986). Natu-

ral questions to ask are (1) whether uniform pricing performs better than spatial price discrimination and (2) whether firms have an incentive to commit to uniform pricing (see Thisse and Vives, 1988, de Fraja and Norman, 1993, Norman and Thisse, 1996, Eber, 1997, Aguirre, Espinosa, and Macho-Stadler, 1998, Tabuchi, 1999). These papers only consider transactions between retailers and consumers and thus price discrimination in the downstream market whereas our focus is on the pricing policies in the upstream market. In our model, retailers can follow different pricing policies upstream. In the downstream market, retailers use uniform pricing. In contrast to models in which firms follow different price policies in the downstream market (see, for instance, Thisse and Vives, 1988), we obtain pure-strategy equilibria at the stage where prices are chosen simultaneously after firms have committed to different pricing policies in the upstream market. Hence, we do not need to impose a leader-follower assumption at the price setting stage when firms use different price policies.

Thisse and Vives (1988) show that firms use spatial price discrimination rather than uniform pricing downstream. This result holds in the unique subgame perfect equilibrium of the three-stage game in which firms first choose location, second commit to a price policy, and third set prices and in which competition is modeled according to the quadratic Hotelling model with constant marginal costs (see Eber, 1997). However, Eber (1997) has also shown that this result depends on the order of moves, namely, if stages 1 and 2 are reversed firms commit to uniform pricing. Taking this alternative order of moves we show that the strategic advantage of uniform pricing dominates the cost disadvantage so that both firms commit to uniform pricing in the upstream market at the first stage of the game. We find that our result does not depend on whether firms first commit to price policies or choose locations.

Also, we would like to point out that in contrast to most papers in the Hotelling tradition we allow for firms to locate outside the area in which consumers “live”. That is, we do not want to rule out that retailers locate outside town. This generates more differentiation possibilities for retailers.

The paper is organized as follows. In Subsection 2.1 the basic model is presented under uniform pricing, and in the Subsections 2.2 and 2.3 the model is solved under two different assumptions on the locations of manufacturers. In Section 3 different price policies are analyzed. Section 3.1 compares price discrimination to uniform pricing in the upstream market. Section 3.2 examines the strategic choice of price policies. Section 4 concludes.

2. Uniform Pricing

2.1. Model and Benchmark

In this section we present the model under uniform mill pricing. This means that retailer i charges the same mill price p_i to the consumers independent of their location; the full price a consumer pays is equal to the mill price plus the transportation cost. Retailers pay a uniform price w_i to suppliers who have to bear the transportation cost to the retailer. Note that different transportation costs will be analyzed to capture possible differences in costs to ship the product from the producer to the retailer and from the retailer to the consumers. We assume that transportation costs are quadratic. The transportation cost for a consumer located at x buying at a retailer located at l_i is $t_1(l_i - x)^2$. Correspondingly, a manufacturer has to pay transportation cost $t_2(l_i - x)^2$.

Consumers are uniformly distributed over the unit interval, $x \in [0; 1]$ and each consumer has a reservation price r for the good at the ideal location x . We will implicitly assume that r is sufficiently high such that, in equilibrium, all consumers want to buy from one of the retailers, that is, the market is covered. A consumer will buy from retailer A if his net utility is larger than the net utility to buy from retailer B, that is,

$$r - p_A - t_1(l_A - x)^2 \geq r - p_B - t_1(l_B - x)^2;$$

Solving this inequality we obtain demand functions for the two retailers,

$$\begin{aligned} q_A^D(p_A; p_B; l_A; l_B) &= \frac{p_B - p_A}{2t_1(l_B - l_A)} + \frac{l_A + l_B}{2}; \\ q_B^D(p_A; p_B; l_A; l_B) &= \frac{p_A - p_B}{2t_1(l_B - l_A)} + 1 - \frac{l_A + l_B}{2}. \end{aligned} \quad (2.1)$$

Possibly, supply is insufficient to cover demand. In this case we assume that rationed consumers cannot switch to the competitor, that is, a consumer who cannot buy from his preferred retailer does not buy at all. In our locational model this can be motivated by saying that consumers always buy from their preferred retailer independent of the risk to be rationed. They make the journey to one of them and are constrained not to go to the other in case the good was not available at the location they tried first. Note that rationing of consumers does not occur in equilibrium.²

²For a Bertrand-Edgeworth model with differentiated products see for instance Canoy (1996). – Our assumptions on consumer demand can be rationalized for certain parameter constellations of the model. To do so, an essential assumption would be that the marginal consumer who is indifferent between the two retailers is never rationed.

Since manufacturers do not enjoy market power, they take the price p_i as given. Profits of manufacturer located at x which produces for retailer i are

$$\pi_{x,i}(p_i; l_i) = p_i - t_2(l_i - x)^2 - c, \quad x \in \mathbb{R}, i = A, B:$$

We assume that manufacturers for each retailer i are uniformly distributed over a compact subset of the reals. In order to restrict the number of parameters of the model, we assume furthermore that the density of the manufacturers' location is 1. A manufacturer at location x is willing to produce and sell to retailer i if

$$p_i - t_2(l_i - x)^2 - c \geq 0:$$

This participation constraint translates into a supply function for retailer i , denoted by $q_i^S(p_i; l_i)$. Its particular form depends on the distribution of manufacturers. We will consider two cases of manufacturer locations. In the first case they are distributed uniformly on an interval which includes any relevant area for a given retailer location l_i , that is, there are always producers on both sides of any relevant location of retailer i , and we can assume that the interval is $X_i(l_i) = [l_i - 1/2; l_i + 1/2]$. In the second case manufacturers are distributed in the same area as consumers, that is $x \in [0; 1]$.

We can write the profit function of retailer i as

$$\pi_i^0(p_A; p_B; l_A; l_B) = p_i \min\{q_i^D(p_A; p_B; l_A; l_B); q_i^S(p_i; l_i)\} - l_i q_i^S(p_i; l_i):$$

Clearly, given locations $l_A; l_B$ the best response of retailer i to prices $p_j; l_j$ are prices $p_i; l_i$ such that $q_i^D(p_A; p_B; l_A; l_B) = q_i^S(p_i; l_i)$. This implicitly defines a function $\beta_i(p_A; p_B; l_A; l_B)$. Hence, along their best response at the price competition stage we can write retailer i 's profits as

$$\pi_i(p_A; p_B; l_A; l_B) = (p_i - \beta_i(p_A; p_B; l_A; l_B))q_i^D(p_A; p_B; l_A; l_B): \quad (2.2)$$

As a first benchmark consider the standard Hotelling model as presented by D'Aspremont, Gabszewicz and Thisse (1979). In our model this corresponds to the case $t_2 = 0$. In this section we do not impose any restriction on the locational choice of retailers, so they may locate outside the support of the distribution of consumers' locations. In this case retailers locate at $l_i = 1/4$ and $5/4$ in unique subgame perfect equilibrium (in pure strategies). Retailers make equilibrium profits $(3/4)t_1$. The fact that retailers locate outside the $[0; 1]$ -interval is an artifact of the assumption of a uniform distribution; for other distributions retailers would locate within the support of the distribution of consumers' locations. If retailers were restricted to locate in the $[0; 1]$ -interval, they would choose locations at 0 and 1 respectively, in the unique subgame perfect equilibrium of the game and obtain profits $(1/2)t_1$.

2.2. Localized, but unconstrained supply

Consumers are uniformly distributed over $[0; 1]$, and manufacturers of retailer i are uniformly distributed over the compact interval $X_i(l_i)$. A manufacturer of retailer i supplies its product if $l_i - t_2(l_i - x)^2 - c \geq 0$. Hence, supply is provided for retailer i by manufacturers located at x if

$$l_i - \frac{p_i - c}{t_2} \leq x \leq l_i + \frac{p_i - c}{t_2}.$$

Since manufacturers are uniformly distributed on any interval in the neighborhood of the location of the retailer with density $f(x) = 1$, we obtain supplies as

$$\begin{aligned} q_A^S(l_A; l_B) &= \int_{l_A - \frac{p_A - c}{t_2}}^{l_A + \frac{p_A - c}{t_2}} dx = \frac{2(p_A - c)}{t_2}; \\ q_B^S(l_B; l_A) &= \int_{l_B - \frac{p_B - c}{t_2}}^{l_B + \frac{p_B - c}{t_2}} dx = \frac{2(p_B - c)}{t_2}. \end{aligned}$$

In any best response, retailer i sets its wholesale price p_i such that $q_i^D(p_A; p_B; l_A; l_B) = q_i^S(p_i; l_i)$. This gives wholesale prices

$$p_i(p_A; p_B; l_A; l_B) = c + \frac{t_2}{4} \frac{\bar{A}}{2t_1(l_B - l_A)} + \frac{l_A + l_B}{2} p_i^2; \quad (2.3)$$

Substituting the expressions from equations (2.1) and (2.3) we obtain profit functions (2.2) as a function depending on the variables $p_A; p_B; l_A; l_B$ and the parameters of the model. Necessary conditions for an (interior) equilibrium in the price competition stage for given locations are

$$\frac{\partial \pi_i(p_A; p_B; l_A; l_B)}{\partial p_i} = 0.$$

The solution to the system of first-order conditions defines retail prices $p_i^r(l_A; l_B)$. Substituting these prices into the profit functions π_i , gives continuation profit functions $\pi_i(l_A; l_B) \equiv \pi_i(p_A^r(l_A; l_B); p_B^r(l_A; l_B); l_A; l_B)$. Denote $\bar{t} \equiv t_2 = t_1$. Note that in the standard Hotelling model $\bar{t} = 0$. If $\bar{t} = 1$ then consumers and manufacturers use the same transportation technology. We refer to a unique equilibrium if there exists only one equilibrium (in pure strategies) with $l_A < l_B$. We then have the following characterization of equilibrium locations, prices and profits.

Proposition 1. In the model with uniform pricing upstream and downstream and with manufacturers' locations uniformly distributed around retailers' locations with density 1, there exists a unique subgame perfect equilibrium in the

location-then-price game. Equilibrium prices, locations and profits are

$$\begin{aligned} p_i^{\pi\pi} &= p_i^{\pi}(l_A^{\pi}; l_B^{\pi}) = c + \frac{1}{32} \mu \left(3(8 + \theta) + \frac{q}{3(24 + \theta)(8 + 3\theta)} \right) t_1, i = A; B, \\ l_A^{\pi} &= \frac{1}{64} \mu \left(8 + 3\theta \right) + \frac{q}{3(24 + \theta)(8 + 3\theta)} t_1, l_B^{\pi} = 1 - l_A^{\pi}, \\ \pi_i(l_A^{\pi}; l_B^{\pi}) &= \frac{1}{64} \mu \left(24 + \theta \right) + \frac{q}{3(24 + \theta)(8 + 3\theta)} t_1, i = A; B: \end{aligned}$$

We can now compare the locational choice in the presence of uniform pricing and positive transportation costs to the initial benchmark in which $t_2 = 0$. In the standard model of product differentiation the two retailers take two contrary effects into account:

- ² demand effect: according to which shops are willing to locate close to the geographical center (hence, also close to each other) in order to obtain greater demand.
- ² strategic effect: according to which shops are willing to separate from each other in order to relax price competition.

The balancing of these two effects determines where retailers locate. Ignoring the strategic effect, locations remain unaffected for $t_2 > 0$ because the supply conditions do not depend on the retailers' locations. However, it is costly to increase supply because all manufacturers have to be paid more. Hence, retailers compete less aggressively in prices on the product market, supporting higher profits for given locations than in the standard model with $t_2 = 0$. Also, since locating further away from the center is punished less severely by the competing retailer, thus inflicting fewer losses on demand, retailers have a stronger tendency to move apart from each other. In equilibrium, both firms locate further apart, as summarized by the following remark.

Remark 1. Retailers move further apart the larger the transportation cost t_2 upstream, that is,

$$\frac{\partial l_A^{\pi}}{\partial t_2} = (1 - t_1) \frac{\partial l_A^{\pi}}{\partial \theta} < 0 \text{ and } \frac{\partial l_B^{\pi}}{\partial t_2} = (1 - t_1) \frac{\partial l_B^{\pi}}{\partial \theta} > 0:$$

For comparisons, we are particularly interested in the case $t_1 = t_2$. Then the equilibrium characterization of Proposition 1 becomes

$$\begin{aligned} p_i^{\pi\pi} &= c + \frac{t_2}{16} \left(\frac{1}{4} c + 0.06 t_2 \right) \\ p_i^{\pi\pi} &= c + \frac{27 + 5\sqrt{33}}{32} t_2 \left(\frac{1}{4} c + 1.74 t_2 \right) \end{aligned}$$

$$l_A^a = \frac{1}{64}(11 - 5\sqrt{33}) \frac{1}{4} - 0.28, l_B^a = \frac{1}{4} - 1.28$$

$$\frac{1}{4} - 0.84t_2 \quad (2.4)$$

2.3. Localized and constrained supply

In this subsection both, consumers and manufacturers, are located on the interval $x \in [0; 1]$. For a good to be supplied to retailer i by a manufacturer at x one must have $l_i - t_2(l_i - x)^2 - c \geq 0$, as before. A retailer which moves away from the $[0; 1]$ -interval not only has the disadvantage of decreasing the utility of the good for the consumers but in the present setup, in addition, incurs higher costs because it is more costly to ship the good from the manufacturers to the retailer and the retailer pays the transportation cost of the marginal manufacturer to all manufacturers. Note that if $l_A - t_2(l_A)^2 - c > 0$, the manufacturer at $x = 0$ sells to retailer A. We obtain supplies as

$$q_A^S(l_A; l_A) = \int_{l_A - \frac{p_A - c}{t_2}}^{l_A + \frac{p_A - c}{t_2}} dx = \min \left(l_A + \frac{p_A - c}{t_2}; 2 \frac{p_A - c}{t_2} \right);$$

$$q_B^S(l_B; l_B) = \int_{l_B - \frac{p_B - c}{t_2}}^{l_B + \frac{p_B - c}{t_2}} dx = \min \left(1 - l_B + \frac{p_B - c}{t_2}; 2 \frac{p_B - c}{t_2} \right);$$

Following the reasoning in the previous subsection we can characterize the unique equilibrium of the two-stage game.

Proposition 2. In the model with uniform pricing upstream and downstream and with manufacturers' locations $x \in [0; 1]$, there exists a unique subgame perfect equilibrium in the location-then-price stage. For $t_1 = t_2$, equilibrium prices, locations and profits are

$$l_i^a = \frac{1}{4} - c + 0.36t_2, i = A; B,$$

$$p_i^a = \frac{1}{4} - c + 2.17t_2, i = A; B,$$

$$l_A^a = \frac{1}{4} - 1 - \frac{p_A^a}{2} - \frac{1}{4} - 0.104, l_B^a = 1 - l_A^a,$$

$$\frac{1}{4} - 0.91t_2, i = A; B: \quad (2.5)$$

The more complicated characterization for $t_1 \neq t_2$ is relegated to Appendix 1. Comparing characterizations (2.4) and (2.5) we make the following observations. If supply is constrained to the unit interval, firms locate closer to each other than in the unconstrained case. This is not surprising since locating apart is far more costly. In spite of this closer location, wholesale prices are much higher than in the unconstrained case. Note that already at $l_A = 0$ equilibrium wholesale prices

in the constrained case are more than twice the prices in the unconstrained case because transportation costs are convex.

Price-average cost margins are higher in the constrained case although retailers' unit costs, which are equal to wholesale prices, are higher. This is explained by the following two facts: ...rst, both retailers are less aggressive competitors at the pricing stage due to higher marginal costs which retailers have to incur in order to obtain additional supply; and second, the gap between marginal costs and average costs widens. Higher price-average cost margins translate into higher profits.

3. Price policies in the Upstream Market

3.1. Price Discrimination in the Upstream Market

In this section we compare our previous results with the results under spatial price discrimination in the upstream market. In this subsection we consider the retailers' pricing under the hypothesis that they set uniform prices downstream and price discriminate upstream. As in the previous section, we consider two variants of the model, the ...rst in which manufacturers are located around the retailers' locations such that retailers do not face supply constraints in any direction, and the second in which manufacturers are located on the $[0; 1]$ -interval. Each manufacturer is supposed to bear the transportation cost and is offered a price $p_i(x)$ which may depend on its location. We might as well let retailers bear the transportation cost upstream. In this latter case manufacturers would only receive the payment c . As in the previous section, we consider the uniform distribution of manufacturers around any retailers' locations, that is, on $X_i(l_i)$ and the restricted version in which manufacturers are distributed uniformly on $[0; 1]$.

Unconstrained supply. Manufacturers are assumed to be uniformly distributed around any retailers' locations, as it has been assumed in Subsection 2.2. The difference between price discrimination and uniform pricing upstream is that under uniform pricing retailers incur higher costs on average and in the margin because an increase in supply not only raises the price paid for the last unit but also for all inframarginal units. This suggests that price discrimination upstream is beneficial from a monopoly perspective but may reduce equilibrium profits in oligopoly because retailers become more aggressive.

Costs of retailers $i = A; B$ are

$$\begin{aligned} C_A(p_A; p_B; l_A; l_B) &= \int_{q_A^D(p_A; p_B; l_A; l_B)=2}^Z [c + t_2(l_A - x)^2] dx; \\ C_B(p_A; p_B; l_A; l_B) &= \int_{q_B^D(p_A; p_B; l_A; l_B)=2}^Z [c + t_2(l_B - x)^2] dx; \end{aligned}$$

Retailer i maximizes profits with respect to price p_i at the second stage

$$\max_{p_i} p_i q_i^D(p_A, p_B; l_A, l_B) - C_i(p_A, p_B; l_A, l_B);$$

and we obtain unique solutions $p_i^u(l_A, l_B)$. Substituting these prices we obtain reduced profit functions which only depend on location l_A and l_B . We fully characterize the unique subgame perfect equilibrium with price discrimination upstream by the following proposition (recall that $t_2 = \theta t_1$).

Proposition 3. In the model with uniform pricing upstream and downstream and with manufacturers' locations uniformly distributed around retailers' locations with density 1, there exists a unique subgame perfect equilibrium in the location-then-price stage. Equilibrium prices, locations and profits are

$$\begin{aligned} p_i^{uu} &= c + \frac{1}{32} \mu (24 + \theta) + \frac{c}{(72 + \theta)(8 + \theta)} t_1, \quad i = A, B, \\ l_A^u &= \frac{1}{64} \mu (8 + \theta) + \frac{c}{(72 + \theta)(8 + \theta)} t_1, \quad l_B^u = 1 - l_A^u, \\ \pi_i(l_A^u, l_B^u) &= \frac{1}{192} \mu (72 + \theta + 3) \frac{c}{(72 + \theta)(8 + \theta)} t_1, \quad i = A, B: \end{aligned}$$

Comparing Propositions 1 and 3, we observe that given any θ and t_1 equilibrium profits are greater under uniform pricing than under price discrimination. Furthermore, retailers locate further apart under uniform pricing than under price discrimination. In the case $t_1 = t_2$, the equilibrium characterization of Proposition 3 reads

$$\begin{aligned} p_i^{uu} &\frac{1}{4} c + 1.58 t_2; \\ l_A^u &= \frac{3}{64} (3 - \frac{c}{73}) \frac{1}{4} \in [0.26, 1.26]; \\ \pi_i^{uu} &\frac{1}{4} 0.78 t_2; \end{aligned}$$

Compared to the benchmark with $t_2 = 0$, price competition is relaxed due to higher marginal costs. Compared to uniform pricing retailers price more aggressively and this affects equilibrium locations. We observe more differentiation between retailers than in the benchmark and less differentiation than under uniform pricing.

Constrained supply. Suppose that manufacturers of each retailer are uniformly distributed on $[0, 1]$. In this case costs of retailers $i = A, B$ are

$$\begin{aligned} C_A(p_A, p_B; l_A, l_B) &= \int_{q_A^D(p_A, p_B; l_A, l_B)}^1 [c + t_2(l_A - x)^2] dx; \\ C_B(p_A, p_B; l_A, l_B) &= \int_0^{1 - q_B^D(p_A, p_B; l_A, l_B)} [c + t_2(l_B - x)^2] dx \end{aligned}$$

for locations and demand such that retailer A has an incentive to buy from the manufacturer located at 0 and retailer B from the manufacturer located at 1. As in Subsection 2.3 we provide the equilibrium characterization for symmetric transportation costs, that is, $t_2 = t_1$.

Proposition 4. In the model with uniform pricing upstream and downstream and with manufacturers' locations $x \in [0, 1]$, there exists a unique subgame perfect equilibrium in the location-then-price stage. For $t_1 = t_2$, equilibrium prices, locations and profits are

$$\begin{aligned} p_i^{uu} &= c + \frac{39}{25}t_2 = c + 1.56t_2, \quad i = A, B, \\ l_A^u &= \frac{1}{10}, \quad l_B^u = \frac{11}{10}, \\ \pi_i^{uu} &= \frac{17}{24}t_2 \approx 0.71t_2, \quad i = A, B: \end{aligned}$$

Compared to the equilibrium in the unconstrained case we observe that retailers differentiate less and obtain lower profits. Note that profits are lower in the constrained than in the unconstrained case. This is in contrast to our previous result under uniform pricing where profits are higher in the restricted case. Consequently, a change of supply conditions has different effects under price discrimination than under uniform pricing. This can be explained by the fact that changes in the supply conditions have a different impact on the marginal costs under the two pricing policies.

Compared to the equilibrium under uniform pricing as characterized by equations (2.5) we observe that equilibrium locations are only slightly affected. Retailers sell closer substitutes under price discrimination than under uniform pricing. There exist several forces which make firms change their location. Each retailer has an incentive to differentiate itself under price discrimination because this relaxes price competition. The costs which are associated with moving apart are lower under price discrimination than under uniform pricing. However, since the competitor prices more aggressively in the downstream market under price discrimination upstream, a relocation in order to relax price competition is more damaging in terms of profits. Clearly, for fixed locations retailers make lower profits under price discrimination than under uniform pricing. This effect is reinforced by the locational choice of the two retailers.

In the asymmetric case $t_1 \neq t_2$ we obtain locations $l_A = \frac{1}{4} \frac{4 + t_2 + t_1^2}{t_1 + t_2}$ and $l_B = 1 - l_A$. The higher are the transportation costs in the upstream market relative to the cost in the downstream market, the closer the two retailers move to each other. For any t_1, t_2 retailer A locates between 0 and $\frac{1}{4}$. In Appendix 2 we report equilibrium prices $p_i^u(l_A; l_B)$ and continuation profits $\pi_i^u(l_A; l_B)$.

3.2. Choice of Price Policies in the Upstream Market

In this subsection we will explain what happens if a retailer can commit to its price policy before choosing locations. Throughout this subsection we assume that manufacturers and consumers are distributed uniformly on $[0; 1]$.³ Consider first the case where the retailers have to locate in the $[0; 1]$ -interval. In this case for any combination of price policies it is optimal to maximally differentiate on the set of admissible locations. We consider the following three stage game:

Stage 1: Retailers choose their price policy upstream.

Stage 2: Retailers choose the location of their shop on the $[0; 1]$ -interval.

Stage 3: Retailers set simultaneously a uniform price downstream and prices upstream subject to their restriction on price policies.

Which price policy is superior? Note that uniform pricing leads to higher average costs for the retailer, given some quantity to be supplied. Hence, one might expect that uniform pricing performs worse than price discrimination upstream. Clearly, price discrimination wins against uniform pricing for retailer locations in $[0; 1]$ if retailers have chosen different price policies. However, the price discriminating retailer is more aggressive because its marginal costs are lower than the marginal costs for the retailer with uniform pricing. In our model, retailers are much more aggressive when price discriminating with the consequence that both gain if one of them commits to uniform pricing (although clearly the one which does not commit to uniform pricing upstream gains more than its competitor). This is a situation in which the strategic effect dominates the cost effect.

Lemma 1. Assuming that $t_1 = t_2$, retailers make the following profits in subgame perfect equilibrium of the subgame following stage 1 (UP stands for uniform pricing and PD for price discrimination):

	UP	PD
UP	$(3=4)t_2; (3=4)t_2$	$4(7-\frac{6}{17})t_2; 2(42-\frac{17}{6})t_2$ $\frac{1}{4} 0:59t_2; \frac{1}{4} 0:72t_2$
PD	$2(42-\frac{17}{6})t_2; 4(7-\frac{6}{17})t_2$ $\frac{1}{4} 0:72t_2; \frac{1}{4} 0:59t_2$	$0:58t_2; 0:58t_2$

At the location stage with different price policies, we find $\partial \pi_A(l_A; 1) = \partial l_A < 0$ and $\partial \pi_B(0; l_B) = \partial l_B > 0$, that is both firms gain by moving apart. Note that the

³We have checked our qualitative results for the unconstrained case. In particular, it can be shown that also in this case retailers commit to uniform pricing upstream.

commitment to uniform pricing strictly dominates price discrimination at stage 1 when considering profits in subgame perfect equilibrium of the subgame following stage 1. Hence, we obtain the following result.

Proposition 5. Assuming that $t_1 = t_2$, there exists a unique subgame perfect equilibrium of the above three-stage game with $l_A, l_B \in [0; 1]$. In equilibrium, both retailers commit to uniform pricing in the upstream market, that is the strategic effect which makes the retailer less aggressive dominates the negative cost effect due to uniform pricing.

Remark 2. Our result on the choice of price policy is robust to the reversal of stages 1 and 2. Note in particular that in the neighborhood of $(l_A, l_B) = (0; 1)$ both retailers choose uniform pricing in the subgame which follows the locational choice at stage 1.⁴

In what follows, we allow both retailers to locate outside the unit interval. That is, we analyze the three-stage game from above with the modification that the strategy space for both retailers at stage 1 are the reals. The subgames in which both retailers adopt the same price policies have been analyzed in Subsection 2.3 and Subsection 3.1. We have observed that both retailers obtain higher profits under uniform pricing than under price discrimination due to the strategic effect. As above, we investigate whether it is an equilibrium outcome that both retailers commit themselves not to price discriminate at stage 1. For this, we have to reconsider the asymmetric choices of price policies. As explained above, the retailer with uniform pricing upstream is less aggressive than the competitor. This affects the locational decisions of the retailers. Suppose retailer A does not price discriminate. For symmetric locations both, none or one of the retailers has an incentive to deviate from these locations by moving closer to the competitor. If exactly one retailer has such an incentive it is always the retailer with uniform pricing, that is, the less aggressive price setter in the downstream market.

In the asymmetric case expressions become too complicated to solve for equilibrium locations algebraically. However, there exists a unique price equilibrium for each pair of locations we obtain explicit expressions for equilibrium prices $p_i^u(l_A, l_B)$. At the location stage, we obtain the equilibrium candidates by finding the zeros of the system of two first-order conditions which follow from maximizing continuation profits $\pi_i(l_A, l_B)$ with respect to l_i . We tried many parameter constellations t_1, t_2 and always obtained a unique admissible solution, and this solution is a global maximizer.

⁴As mentioned in the introduction, Eber (1997) pointed out that the equilibrium choice of price policy downstream depends on the order of stages 1 and 2. (His model corresponds to our model with $t_2 = 0$.)

Lemma 2. Assuming that $t_1 = t_2 = 1$, retailers make the following profits in subgame perfect equilibrium of the subgame following stage 1 (with equilibrium locations in brackets):

	UP	PD
UP	0.91; 0.91 (; 0.104; 1.104)	0.84; 0.73 (0.005; 1.200)
PD	0.73; 0.84 (1.200; 0.005)	0.71; 0.71 (; 0.100; 1.100)

Note that under symmetric costs, $t_1 = t_2$, equilibrium locations are independent of the scaling parameter of the transportation costs and the profit ranking generalizes to any symmetric case. Surprisingly, in the off-diagonal entries the retailer with uniform pricing obtains higher profits than the retailer with price discrimination so that the profit ordering is reversed compared to the case where both retailers locate in the $[0; 1]$ -interval. Also, the retailer with uniform pricing, say retailer A, locates in the interior of the interval. It might surprise that retailer A locates in the interior of the support of the consumer density whereas it locates on its boundary when retailers were restricted to locate in $[0; 1]$. Consider the initial situation $(l_A; l_B) = (0; 1)$. Note that $\arg \max_{l_A} \pi_A(l_A; 1) \approx 0.044$ and $\arg \max_{l_B} \pi_B(0; l_B) \approx 1.200$. The aggressive retailer B gains from committing to price less aggressively by locating further apart. This also holds for retailer A, but its optimal deviation is much less than the optimal deviation of retailer B. Recall that retailer A's costs are very sensitive to reaching out to suppliers which are further away. Retailer A has therefore a stronger incentive to locate inside the support of the density function according to which manufacturers are distributed. This explains why it happens that, in equilibrium, retailer A locates in the interior of the unit interval for $t_1 = t_2$. Also, it is retailer A who mainly benefits from these new locations compared to $(0; 1)$. Its increase in profits is so strong that the profit ordering between the two retailers is reversed. We obtain that uniform pricing is chosen in the unique subgame perfect equilibrium of the three stage game.

Proposition 6. Assuming that $t_1 = t_2$, there exists a unique subgame perfect equilibrium of the above three-stage game with $l_A; l_B \in (0; 1)$. In equilibrium, both retailers commit to uniform pricing in the upstream market.

Our remark on the robustness to the order of stages 1 and 2 also applies here. The above result also holds for asymmetric transportation costs $t_1 \neq t_2$, as we have checked for different parameter constellations. Clearly, with asymmetric transportation costs equilibrium locations and profits in the subgame which follows stage 1 are different from the ones reported in Lemma 2 above. In the

case of different price policies retailer A does not necessarily locate in the interior of the unit interval. Also, for certain other parameter constellations the distance between the two retailers becomes less than 1.

4. Conclusion

In this paper we have analyzed a model of spatial competition in which two retailers operate in a monopsonistic, oligopolistic environment. They have to buy from spatially dispersed suppliers and use uniform pricing downstream.

First, we have characterized the equilibrium in the two-stage location-then-price game under uniform pricing in the upstream market. We analyze how local supply conditions affect equilibrium locations and profits. Compare the case in which supply is only available from the area in which consumers are located to the situation in which supply is available everywhere. In the first case average and marginal costs of production are higher if a retailer is located outside the area in which consumers are located. In equilibrium, retailers locate closer to each other. In spite of locating closer to each other, their profits are larger than in the equilibrium with unconstrained supply. This is due the strategic effect of higher marginal costs at the pricing stage.

Second, we have analyzed spatial price discrimination in the upstream market and the strategic choice of price policy. Given locations, costs for a given quantity are significantly less convex for a retailer under spatial price discrimination than under uniform pricing. This makes retailers more aggressive at the price stage. In equilibrium, retailers earn lower profits under spatial price discrimination than under uniform pricing. This holds although retailers enjoy lower total costs under spatial price discrimination. In the setup in which retailers choose price policy at an initial stage we have shown that retailers commit to uniform pricing in the upstream market.

We have considered an environment in which a single retailer which enjoys monopoly power on both sides of the market and has to use uniform pricing in the downstream market would choose spatial price discrimination rather than uniform pricing in the upstream market. We have shown that, in equilibrium, imperfect competition in the downstream market leads retailers to opt for uniform pricing rather than spatial price discrimination in the upstream market. Imperfect competition reverses the result on the optimal price policy under monopoly framework: uniform pricing strictly dominates price discrimination.. We expect that our results on the choice of price policy also hold in an oligopoly framework with localized competition such as the circular city (Salop, 1979, Economides, 1989).

A potential topic for future research might be to consider price policies as

endogenous on both sides of the market. We would be very interested in such an analysis if one could draw general conclusions in such an environment.

APPENDIX

Appendix 1

Continuation profits are

$$\pi_i(l_A; l_B) = \frac{t_1(l_A - l_B)(2 + \theta)(1 - 3l_B(1 + \theta) + l_A(3 + \theta))}{3(2(\theta + l_A(3 + 2\theta) + l_B(3 + 2\theta))^2)} \\ E[2\theta - 4l_A(1 + \theta) + l_A^2(1 + \theta) + l_B(4 - l_B + \theta(2 - l_B))] :$$

At stage 1 retailers choose locations:

$$l_A^* = 1 - \frac{7+5\theta + \sqrt{9+14\theta+9\theta^2}}{8(1+\theta)}; \quad l_B^* = \frac{7+5\theta + \sqrt{9+14\theta+9\theta^2}}{8(1+\theta)}.$$

For these locations we obtain prices and profits

$$p_A^{**} = p_B^{**} = c + \frac{t_1(24 + 53\theta + 34\theta^2 + 9\theta^3 + (8 + 5\theta(3 + \theta))\sqrt{9 + \theta(14 + 9\theta)})}{32(1 + \theta)^2};$$

$$\pi_i(l_A^*; l_B^*) = \frac{1}{16}(t_1(4 + \theta) + \frac{t_1(2 + (2 + \theta)\sqrt{9 + 14\theta + 9\theta^2})}{(1 + \theta)}):$$

Appendix 2

Continuation profits are

$$\pi_i(l_A; l_B) = \frac{t_1(2 + (l_A + l_B)(1 + \theta))^2(2\theta - (l_A + l_B)(18 + \theta(7 + \theta)))}{12(3 + \theta)}:$$

In subgame perfect equilibrium we obtain prices

$$p_A^{**} = p_B^{**} = c + \frac{t_1(2 + \theta)(3 + \theta)(16 + 26\theta + 9\theta^2 + \theta^3)}{4(1 + \theta)^2(4 + \theta)^2}$$

and profits

$$\pi_i(l_A^*; l_B^*) = \frac{9t_1^2 + 7t_1^2\theta + (t_1\theta)^2}{12t_1(1 + \theta)}:$$

References

- [1] Aguirre, I., M.P. Espinosa, and I. Macho-Stadler (1998), "Strategic entry deterrence through spatial price discrimination", *Regional Science and Urban Economics* 28, 297–314.
- [2] Bester, H. (1998), "Quality Uncertainty Mitigates Product Differentiation", *Rand Journal of Economics* 29, 828–844.
- [3] Böckem, S. (1994), "A generalized model of horizontal product differentiation", *Journal of Industrial Economic* 42, 287–298.
- [4] Canoy, M. (1996), "Product differentiation in a Bertrand-Edgeworth duopoly", *Journal of Economic Theory* 70, 158–179.
- [5] Champsaur, P. and J.-C. Rochet (1989), "Multiproduct Duopolists", *Econometrica* 57, 533–557.
- [6] D'Aspremont, J., J. Gabszewicz and J.-F. Thisse. (1979), "On Hotelling's 'stability in competition' ", *Econometrica* 47, 1145–1150.
- [7] De Fraja, G. and G. Norman (1993), "Product differentiation, pricing policy, and equilibrium", *Journal of Regional Science* 33, 343–363.
- [8] De Palma, A., V. Ginsburgh, Y.Y. Papageorgiou, and J.-F. Thisse (1985), "The Principle of Minimum Differentiation Holds under Sufficient Heterogeneity", *Econometrica* 53, 767–781.
- [9] Eber, N. (1997), "A Note on the Strategic Choice of Spatial Price Discrimination", *Economics Letters* 55, 419–423.
- [10] Economides, N. (1986), "Minimal and Maximal Product Differentiation in Hotelling's Duopoly", *Economics Letters* 21, 67–71.
- [11] Economides, N. (1989), "Symmetric equilibrium existence and optimality in differentiated product markets", *Journal of Economic Theory* 47, 178–194.
- [12] Greenhut, J.G. and M.L. Greenhut (1975), "Spatial price discrimination, competition and location effects", *Economica* 42, 401–419.
- [13] Hotelling, H. (1929), "Stability in competition", *Economic Journal* 39, 41–57.
- [14] Lederer, P.J. and A.P. Hurter (1986), "Competition of firms: Discriminatory pricing and location", *Econometrica* 54, 623–640.

- [15] Norman, G. (1983), "Spatial pricing with differentiated products", *Quarterly Journal of Economics* 97, 291–310.
- [16] Norman, G. and J.-F. Thisse (1996), "Product variety and welfare under discriminatory and mill pricing", *Economic Journal* 106, 76–91.
- [17] Salop, S. (1979), "Monopolistic competition with outside goods", *Bell Journal of Economics* 10, 141–156.
- [18] Spulber, D. (1981), "Spatial nonlinear pricing", *American Economic Review* 71, 923–933.
- [19] Spulber, D. (1999), *Market microstructure: Intermediaries and the theory of the firm*, Cambridge University Press.
- [20] Tabuchi, T. (1999), "Pricing policy in spatial competition", *Regional Science and Urban Economics* 29, 617–631.
- [21] Thisse, J.-F. and X. Vives (1988), "On the strategic choice of spatial price policy", *American Economic Review* 78, 122–137.
- [22] Tirole, J. (1988), *The theory of industrial organization*, MIT Press.